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## Incidence and severity of intravenous drug errors in a German hospital

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**Abstract Objective:** To determine the incidence of errors in preparing and administering intravenous (i.v.) drugs, identify the stages in the process at which errors occurred and evaluate their clinical importance.

**Methods:** A prospective ethnographic study using disguised observation was carried out on two wards in one German non-university hospital.

**Results:** We observed 22 nurses administering 122 i.v. drug preparations and administrations. One or more errors occurred in the preparation and administration of 58 of 122 i.v. drug doses (error rate 48%, 95% confidence interval 39–57%). In total, 65 errors were identified. Of doses, 4 had potentially severe errors (3%), 38 (31%) potentially moderate errors and 16 (13%) potentially minor errors. Common errors included multiple step preparations and the co-administration of potentially incompatible drugs as intermittent infusions.

**Conclusion:** A high incidence of i.v. drug errors was found in the study hospital. Effective strategies to reduce potentially harmful errors are urgently needed. Measures could include a reduction in the number of ward-based i.v. drug preparations, improvement of staff training and the introduction of ward-based clinical pharmacy services.

**Keywords** Medication errors · Intravenous drugs · Germany

### Introduction

The preparation and administration of intravenous (i.v.) drugs are associated with considerable risks. We have recently reported the results of an ethnographic study in two hospitals in the United Kingdom (UK) [1]. We found an error rate of 49%; at least one error occurred in 212 of 430 observed i.v. drug doses. Although most were unlikely to cause lasting harm, 3 errors (1%) were judged to be potentially severe, and 126 (29%) were potentially moderate errors. Most errors occurred when bolus doses were administered too fast or when making up drugs that required multiple step preparations. Two recent studies carried out in three different university teaching hospitals indicated that similarly high i.v. drug error rates occur in Germany [2, 3]; however, there is little information on error rates in other settings, such as non-university hospitals. Furthermore, both German studies only provided limited validated information on the clinical importance of the errors. We, therefore, conducted a prospective observation-based study in a German non-university hospital using the same methods and definitions as in our previous UK study [1]. We determined the incidence of errors in preparing and administering i.v. drugs, identified the stages in the process at which errors occur and evaluated their clinical importance.

### Materials and methods

The study was carried out in a 600-bed hospital, which operated in the typical German traditional ward-stock system, with only limited ward-based clinical pharmacy services [2]. Data were collected on a surgical ward and a surgical intensive care unit, both caring for adult patients. On the surgical ward, doctors recorded prescriptions in the inpatient notes, and these were transcribed by nursing staff onto formatted drug charts. In general, one or two nurses prepared and administered i.v. medication for all patients on the ward. On the intensive care unit, electronic patient records were used, which did not require transcriptions. One nurse cared for one to three patients. Nurses prepared and administered i.v. drugs for their patients.

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The study was approved by the medical, nursing and pharmacy directorate as well as the hospital's quality assurance committee. Study methods and definitions have been reported previously [1]. Briefly, we defined an i.v. drug error as a deviation in preparation or administration of a drug from a doctor's prescription, the hospital's i.v. policy or the manufacturer's instructions. The clinical appropriateness of the prescription was not assessed. A trained and experienced observer (K.T.) accompanied nurses during i.v. drug rounds. Information came from observation and talking informally to staff. She recorded the preparation and administration of each drug on a standard form. Ward staff was told that we were investigating common problems of preparing and administering i.v. drugs. The researcher avoided the word error to prevent the study from appearing threatening to staff; this disguised observation method has been shown to be valid [4]. Each nurse was asked for permission for observation. Data were collected on six or seven consecutive days on each ward, including weekends, in March 2000. Between two and three drug rounds were attended each day.

We used a validated scale to assess the clinical importance of i.v. drug errors [5, 6]. Three experienced health professionals (one doctor, one nurse and one pharmacist) scored the potential clinical importance of each drug error on a visual analogue scale between zero (labelled as no harm) and ten (death). Mean scores below two suggested a minor outcome, scores of two to six a moderate outcome and scores above six a severe outcome.

We expressed data in two ways, errors per dose and errors per process stage. We calculated proportions and confidence intervals using standard methods [7].

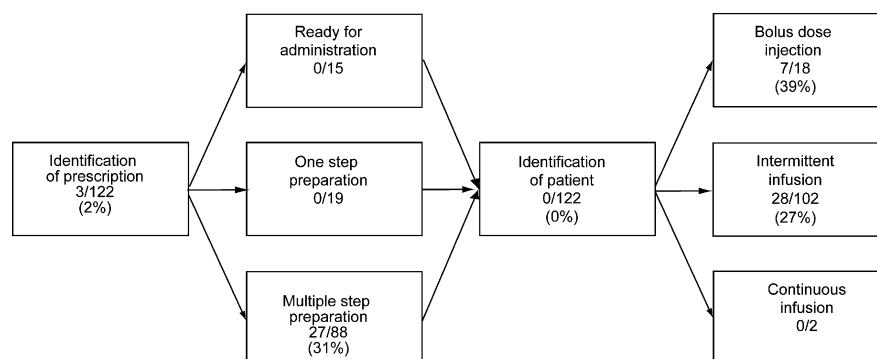
## Results

A total of 22 nurses were observed during the study period. One nurse refused to participate. Altogether, 357 regular i.v. doses representing 18 different drugs were prescribed for 33 patients during the study. Our observations were representative of the study period: 34% (122) of all i.v. doses prescribed were observed; administration of 77% (14) of the prescribed drugs was observed on at least one occasion and 82% (27) of patients who were prescribed regular i.v. drugs were observed at least once. Table 1 shows the number of observations on each ward.

**Table 1** Number of observations by type of ward

Type of ward	Number of observations
Surgical ward	87
Surgical intensive care unit	35
Total	122

**Fig. 1** Stages and errors in preparation and administration of intravenous drugs (number of errors/number of observations of each stage)



One or more errors occurred in the preparation and administration of 58 of 122 i.v. drug doses (error rate 48%; 95% confidence interval 39–57%). A total of 65 errors were identified. Preparation errors occurred in 23 i.v. doses (19%), administration errors in 28 doses (23%) and both types of errors in 7 doses (6%). Errors were potentially severe in 4 doses (3%), potentially moderate in 38 (31%) and potentially minor in 16 (13%). Figure 1 shows the incidence of errors at each stage of drug preparation and administration. Table 2 gives a more detailed analysis of the type and severity of the errors. Most preparation errors were associated with multiple step preparations—for example, drugs that required reconstitution with a solvent and addition of a diluent. A typical error was preparing a drug using the wrong solvent, but the majority of these errors were judged to be of minor clinical importance. Errors of moderate severity included the administration of an unauthorised drug or the omission of medication. Both types of errors were due to errors in transcribing drug orders onto the drug charts. The majority of errors were co-administrations of drugs as intermittent infusions that were potentially incompatible or where no information on the compatibility was available. This included three potentially severe errors. An example of the latter was the co-administration of propofol, midazolam and piritramid through the same central catheter. It is recommended that propofol be administered through a separate catheter. Only few drugs were administered as bolus doses, as hospital policy did not allow nurses on the surgical ward to inject bolus doses. The doctors prescribed the majority of such drugs to be administered as intermittent infusions. Bolus dose errors on the intensive care unit included the administration of piritramid (an opioid analgesic) over 1 s, which was judged to be a potentially severe error.

## Discussion

We found a high incidence of errors in the preparation and administration of i.v. drugs in a German hospital. About one-third of all i.v. doses were associated with a potentially harmful error. We have identified three weak stages in the process: doses that require multiple step preparations, the administration of bolus dose injections

**Table 2** Type and clinical importance of errors in preparation and administration of intravenous drugs. Values are numbers (percentages) of errors in 122 observations

Type of error*	Importance of errors			
	Minor	Moderate	Severe	Total
<b>Preparation errors</b>				
Errors in solvent/diluent	22 (18)	2 (2)	0	24 (20)
Wrong dose	0	3 (2)	0	3 (2)
Omission	0	1 (1)	0	1 (1)
Unauthorised drug	0	2 (2)	0	2 (2)
<b>Administration errors</b>				
Fast bolus dose (central line)		2 (2)	1 (1)	3 (2)
Incompatibilities		28 (23)	3 (2)	31 (25)
Other		1 (1)		1 (1)

\*No errors were observed in the categories of preparing the wrong drug or administration to the wrong patient

and the administration of intermittent infusions. Similar types of preparation errors were observed in our UK study. We have already discussed several strategies to reduce such errors, including better training of nurses in preparation processes and the use of ready-prepared drugs by the pharmacy department or the industry [1, 8]. In the German hospital, the majority of errors at the administration stage involved the administration of potentially incompatible drugs. All of these errors were judged to be potentially harmful, including permanent harm. Few such errors were observed in our UK study [1]. This may be partly due to clinical pharmacists providing information on common incompatibilities at the ward level in the UK study hospitals; whereas, no such service was available on the German wards. Clinical pharmacists can take up this role in German hospitals, as has been shown in one study [9]. Nursing staff on the surgical ward was required to transcribe drug orders from the medical notes onto drug charts. Several errors occurred in this process. Again, no such error was identified in the UK study hospitals, since original drug orders were used during drug preparation and administration. Electronic prescribing, as used on the intensive care unit in the German study hospital, may also prevent this type of error. The majority of errors in the UK study were associated with fast administration of bolus

doses. A high rate of bolus dose errors was also observed on the German wards, but relatively few bolus dose administrations were observed; hence, data on this type of error may not be comparable.

The present study, as well as two previous German studies [2, 3], suggest that i.v. medication errors are common in German hospitals. Measures to improve the safety of i.v. drug preparation and administration seem to be needed urgently. A comparison of German and UK practices showed strengths and weaknesses of each system. Measures to reduce the number of i.v. medication errors in Germany may include reducing the number of ward-based i.v. drug preparations, improving staff training and introducing ward-based clinical pharmacy services.

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